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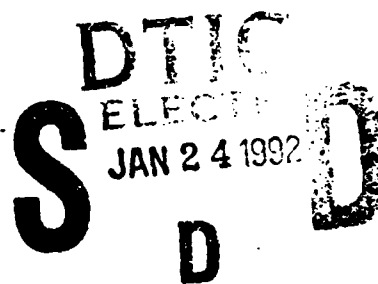
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Decision Making in Teams: Raising an Individual

Decision Making Model to the Team Level

Daniel R. Ilgen, Debra A. Major,

John R. Hollenbeck, & Douglas J. Sego



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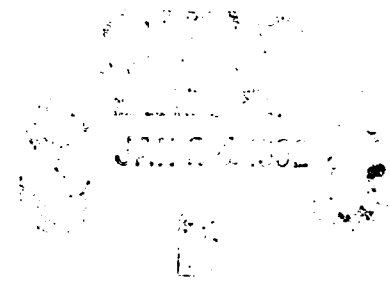
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13. ABSTRACT (Maximum 200 words) A model of team decision making based on an individual decision making model is developed. The team model focuses on how individual team members use informational cues to reach judgments that are incorporated into team decisions. The notion of distributed expertise illustrates the allocation of critical information across team members. The model specifically addresses the decision making processes of hierarchical teams in which there is one identified leader or decision maker for the team. In addition, this report describes an experimental paradigm for the study of team decision making under conditions of distributed expertise. Level of analysis issues in the study of team decision making are also discussed.				
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Decision Making in Teams: Raising an Individual

Decision Making Model to the Team Level

" 'The Right Stuff.' Does U.S. industry have it? With teamwork and new ideas, GM's Saturn aims to show that the American manufacturers can come roaring back." (cover story, Time, October, 29, 1990, emphasis added)

" 'Who Needs a Boss?' Not the employees who work in self-managed teams. They arrange schedules, buy equipment, fuss over quality -- and dramatically boost the productivity of their companies." (cover story, Fortune, May 7, 1990, emphasis added)

As the decade of the 1980s ended and the 1990s began, a great deal of attention was focused on work teams. Several factors contributed to the interest. Economic setbacks in U.S. manufacturing provided an impetus for introspection with a search for sources to which to attribute a perceived decline in the productivity of the U.S. workforce. Not surprisingly, this search led to comparisons with international competitors in an attempt to discover what they were "doing right." Rightly or wrongly one of the commonly held beliefs was that a major competitor, Japan, was successful, in part, because teamwork seemed to be stressed over individualism in Japanese organizations. This, along with highly publicized work redesign projects that organized production around work teams, such as the Volvo car manufacturing plant in Sweden and General Motor's Saturn plant, led to heightened interest in teams at work. Cover stories of leading news and business magazines quoted above attest to the high level of interest in the use of teams in the workplace.

Highly visible team failures provided a second source of interest in teams. At least two civilian airline accidents resulted from breakdowns in the team routines of cockpit crews. In one case, pre-flight procedures designed to assure proper procedures by having one team member read a check list and the other verbally report the switch settings failed to detect an error that should have been obvious. As the plane sat on the runway in a blinding snowstorm, the reader of the check list asked, "De-icer?" The other crew member responded, "off." Neither member of a flight crew that flew almost all of its flights in the southeastern United States where "off" is typically the proper setting for all take-off conditions, detected the incorrect setting. The cooperative team task of reading and responding to a check list failed to insure safety. In another air disaster, there was reason to suspect that casual conversations among crew members prior to take-off distracted the crew from carefully attending to the pre-flight routine. Finally, in the most publicized of all team errors, a command and control team of the Vincennes, a U.S. Naval vessel stationed in the Persian Gulf in July of 1988, mistakenly identified an Iranian commercial airliner on a routine flight as a hostile military aircraft and shot it down. The combination of the tragic loss of human life and international political ramifications of this incident led to a number of investigations within the military, by the U.S. Congress, and in many other forums.

Common to all the teams just described is the need to make team decisions. The establishment of teams in the workplace shifts decision-making responsibility for many decisions from supervisors and middle management to teams of workers directly involved with the organization's primary objective--the production of goods or services. Cockpit crews and command-and-control teams coordinate information and then make decisions critical to the operation of the aircraft or unit. In all cases, information is processed by individuals, shared among them in some fashion, and decisions or judgments are rendered that represent the result of some collective team actions. One clear message from all of the recent interest in teams is that there is a strong need for a better understanding of team functioning and decision making in all kinds of situations and conditions, particularly conditions of high stress. It is in the spirit of this latter conclusion that this chapter was written.

Team Decision Making: Definitional Issues

Teams

Research and writing on issues related to teams appears in the literature under the topics of teams or small groups, with a far larger proportion of the work falling under the latter heading. McGrath (1984) concluded, from a review of the small group research, that virtually all definitions of small groups included three characteristics: (1) two or more individuals, (2) interaction among group members and (3) interdependence among them

in some way. To these three, McGrath added that they exist in some time frame. That is, they have a past, a present and a future. Both the past and the anticipation of the future will influence the present behaviors of small group members. Left unanswered was the question of how small is small? Most would agree that small groups are small enough that all group members can be aware of and know the others, but the exact limits of size depend upon other factors, such as the nature of the task or the amount of interaction. We too will leave the size limit open, with a lower bound exception. Dyads are often considered teams. We have chosen to exclude them because there are a number of important team processes that do not occur in dyads, such as coalition formation and complex patterns of status and communication. We recognize that the exclusion of dyads is arbitrary, but it is consistent with the types of team problems that we have chosen to address.

From our perspective, teams share the above characteristics with small groups, and yet the three characteristics above ignore one additional characteristic. This is, teams exist for some task-oriented purpose. They design buildings, plan fund raising campaigns, play basketball games, et cetera. Typically, they do not exist for purely social reasons. One may consider four or five good friends who gather every Friday after work to be a small group, but rarely would such a group be considered a team. For teams, there are explicit goals and, with few exceptions, the

members of the teams have some level of awareness of the team goals. Thus, when we speak of teams in work-oriented organizations, we add a fifth defining characteristic, that of shared goals. The definition of a team that most closely captures that which we will assume for our discussion is taken from Morgan, Glickman, Woodard, Blaiwes and Salas (1986) which states that teams are, "distinguishable sets of [more than two] individuals who interact interdependently and adaptively to achieve specified, shared and valued objectives." (p. 3).

Team Decision Making

Decision making falls within a family of loosely related theoretical perspectives and research paradigms known as information processing (Lachman, 1987). These theories are concerned with how individuals select and process information to be used either at that time or later to make decisions, typically called judgments. The complexities of individual decision making are enormous, both in terms of the nature of information that is available to individuals and in the way in which people process it by attending, coding, storing, recalling, and combining the information to reach decisions.

All individual decision making models or theories share two basic assumptions. The first of these is that individuals base their decisions on some finite set of elements, often called cues.¹ Second, it is assumed that individuals combine these cues in some fashion to reach decisions. Beyond these two, the

communality breaks down often on the basis of assumptions of what constitutes the criteria for judging the quality of a decision. Two decision-making models dominate, one based on the use of conditional probabilities (the Baysean Model) and the other based on a regression model with weights for cues and the combination of cues (the Brunswik Lens Model). The team decision making model to be developed later in this chapter is an adaptation of the lens model. In the lens model, it is assumed that some set of cues exists that is relevant to a particular decision either individually or in interaction with each other, and furthermore, that the weights for the cues and their interactions are known or can be discovered.

As if individual decision making were not complex enough, team decision making adds a number of other complexities. Although the decision itself can be raised to the level of the team by simple analogy, the fact remains that team decisions are still made by members of the team working together. Thus, team decision making is a multi-level phenomenon that must take into account individual and team processes. At the individual level, each team member may reach a decision based on some consideration of a set of cues and their weights, but, within the team, individual members may have information about different cues. Individuals within the team may also have different weights for the same cues. The nature of the distribution of knowledge about cues and their weights and the nature of the interaction among the

team members in the decision process is, in part, a function of a priori roles and individual differences. Consider, for a moment, the decision to purchase a new production robot to be made by a team which includes a design engineer, a manager of the production unit that will use the robot, a purchasing agent, and a person who is to be trained to operate the robot. Together they are to make a team decision about what robotic system to purchase. In such situations, expertise is distributed over team members with no one member possessing all the relevant information. In addition, even when team members have access to the same information, they may evaluate or weigh it much differently. In the case of the robot purchase example, a purchasing agent and a line manager on the team may have very different views about the importance of price in the final decision even when they both have access to the same price information. They also have different areas of expertise, so they can address different domains of the robot purchasing problem. Such situations are termed team decision making under conditions of distributed expertise. In sum, when moving decision making to the team level, there are both individual and team level constructs that are derived from the decision process itself.

In addition to decision making constructs, there are other uniquely team level constructs that impact on decisions and have no individual level analogues. Such constructs as trust in others, cooperation, coordination, and power or status differences among team members exist within teams. The team level variables

may impact team decisions either directly or in interaction with individual variables. For example, the power or status of an individual may have a direct effect on a team's decision by increasing the weight given to judgments of people in high power positions within the team whereas trust among members may interact with the mean ability level of the team such that under conditions of high trust and high ability the teams do well but under low trust they do not do well regardless of the mean ability level. Clearly, team level variables do impact on team decisions.

In the remainder of the chapter, we shall focus on decisions that are made by teams. That is to say, although individuals in the team contribute to the decision, a decision is reached which is attributed to the team rather than an individual or individuals in the team. Depending on the team decision making structure, the way that team members contribute to the team decision will vary. But it is assumed that more than one of the team members' judgments will be expressed and, in some fashion, contribute to the overall decision for the team. Before we turn to the development of the model, we will briefly (and selectively) review past research on team decision making as a background for considering the approach taken here.

Past Approaches to Team Decision Making

A great deal of work exists on team decision making. Much of which appears under the rubric of group decision making. Regardless of the label, if the work involved a set of individuals

who interacted interdependently and adaptively to reach some decision, we considered it team decision making for the purpose of our discussion. We have taken the liberty of referring to the collectives as teams even when the authors labeled them groups, if the collectives fit our definition of teams.

Team Decision Making Criteria: Internally Referenced

Virtually all research on team decision making is concerned about some outcome of the decision making process. The outcomes can be classified in two sets. One set is concerned with outcomes of the decision making process or the feelings and reactions of the team members that result from reaching decisions in teams. In a sense, these outcomes are referenced internally (internal to the team itself). The other set deals with the quality of the decision as judged against some standards or criteria external to the team. The vast majority of research deals with internally referenced criteria. That is to say, the primary concern of most of this research is with team decision making processes. Methods by which team members share unique information (Stasser & Titus, 1985), use available information (Argote, Seabright, & Dyer, 1986) and use feedback (Tindale, 1989) are just a few examples of some of the process factors studied. Two examples of internally referenced work are addressed below.

Consensus is one of the most commonly investigated internal criteria and is perhaps most thoroughly researched in the jury decision making literature (see Gerbasi, Zuckerman, & Reis, 1977;

Penrod, & Hastie, 1979; Stasser, Kerr, & Bray, 1982; Stasser, Kerr, & Davis, 1989). Typically, in this research, a particular consensus rule is described or proposed, and teams (real or mock juries) are observed with respect to the extent to which the teams use the rule and with respect to the factors that influence the use of the rule.

Other consensus research has varied the composition of teams and looked at the effect of the homogeneity or heterogeneity of team members on some selected individual difference variables. Liddell and Slocum (1976) studied the effects of the degree of personality and role compatibility on team decision making effectiveness. They assessed group members with respect to the amount of control desired and the amount bestowed on them by role requirements. Compatible groups, defined as those in which high control individuals were able to have the most influence and low control ones were not required to exert influence, made faster decisions and fewer errors on a symbol identification task.

Coalition Formation. A related line of research concentrates on the nature of coalitions that are formed among team members who have to reach a decision and the effects of such coalitions on the decisions that are made. (See Komorita, 1984, for an excellent review of the coalition formation literature.) In coalition formation research, members of teams are required to make choices, and the variable of interest is who aligns with whom within the group to reach a decision. Individual team members are

typically viewed in terms of the resources that they possess and the power that they wield within the team as a result of these resources. As is the case with most of the internally referenced criteria, the decision reached by the team is of less interest than is the way in which the team reaches that decision.

Team Decision Making Criteria: Externally Referenced

In contrast to internally referenced criteria are externally referenced ones that focus on the quality of decisions resulting from the team decision making process. In this case, some external standard exists for evaluating the decision that is reached. Teams are studied with respect to the quality of their decisions either against the standard itself, relative to other teams, or relative to an equal number of individuals who work on the task alone. An example of the latter is research that compared the quality of team decisions made by consensus (having all team members reach a common agreement) to the quality of individual decisions (e.g., Argote, Devadas, & Melone, 1990; Yetton & Bottger, 1982) or other research that looked at decision quality related to the nature of team consensus (e.g., Castore & Murnighan, 1978; Snizek & Henry, 1989; 1990).

When the task of a team has a major decision component, and the performance of the team is a function of the quality of team decisions, research on team performance fits into the category of externally referenced criteria for team decisions. Only research in which team performance is judged according to some pre-

established quality standards fits into this category. The work of Laughlin and his colleagues is a good example of such research (Laughlin, 1980; Laughlin & Adamopolus, 1980; 1982; Laughlin, Kerr, Davis, Halff, & Marciniak, 1975; Laughlin, Kerr, Munch, & Haggarty, 1976). For instance, Laughlin et al. (1975) used a difficult English vocabulary test to examine the performance of teams consisting of two to five members. The test had objectively correct answers, and the researchers found that a "truth wins" process was the best representation of the groups's decision process. That is, once the correct answer was proposed, the group typically reached consensus. Similar results were obtained in studies using a more extensive verbal achievement test (Laughlin et al., 1976) and a verbal analogies test (Laughlin & Adamopolus, 1980).

In spite of the dominating interest in team performance and the fact that decisions are likely to play a major role in the performance of many teams, there is very little work that combines the two. Typically, when the interest is in performance, decision making is assumed to be of interest but is not assessed. It is assumed that if the team performed well good decisions were made, and, if it did not, the decision making issues may or may not have been handled well. On the other hand, often when decision making is the focus, subsequent team performance resulting from the decision is not investigated. Assessment of the decision or the way the decision was made completes the investigation without an

evaluation of the quality of the decision. As will be argued below, there currently is some shift in this limited view of team decision making.

Shifts in Approaches to Team Decision Making

More recently, we have seen a heightened interest in teams that make important decisions and in actual decisions that have externally referenced criteria. As mentioned before, much of the interest has been stimulated by things "gone wrong," -- a failing economy, airline accidents, military mistakes, and so forth. In all cases, the decisions were evaluated against external criteria that left no doubts about what was good or bad.

Case Studies. The recent book edited by Hackman (1990) includes a number of examples of teams and team research that fits the current focus. For example, in it Denison and Sutton (1990) describe a case study in which operating room nurses were structured into teams. Increased participation in decision making, opportunities for cross-training and greater flexibility were among the noted advantages of teamwork. In another case, Eisenstat (1990) discussed the start-up of a manufacturing team, including several variables that influenced its success, such as managerial support, availability of expert advice, and a motivating task. For both Denison and Sutton (1990) and Eisenstat (1990) external criteria related to the effectiveness of the functioning of the operating room or the viability of the small business provided the rationale for looking at the teams.

Assuming that the current trend toward increased use of teams in important organizational roles continues, research on teams making critical decisions should increase.

Cockpit crews. Foushee (1982; 1984) has conducted extensive research with the National Aeronautics and Space Administration (NASA). He found that members of crews with higher error rates are more uncertain when responding to task demands, experience greater frustration or anger, more frequently report being embarrassed, and tend to disagree among themselves more frequently (Foushee, 1982). Gregorich, Helmreich, and Wilhelm (1990) have developed an attitudinal instrument directed specifically at cockpit crews (the Cockpit Management Attitudes Questionnaire) to be used to measure attitudes in order to better understand the team processes that are likely to affect decision making in this critical setting under normal and stressful conditions.

Teamwork. Morgan et al. (1986) have begun an equally important line of research aimed at defining and measuring team behaviors. Working inductively from the literature and also from data gathered from extensive interviews, critical dimensions of teamwork have been identified. Then, using an instrument based on what was learned, teams constructed for the purpose of training were evaluated to assess the impact of teamwork dimensions on the quality of team performance on tasks requiring decision making.

The case study, cockpit crew, and teamwork research cited above fit into the domain of team research with externally

referenced criteria. They also deal with team decision making processes. In our opinion, they address several interesting and important team decision making issues. At the same time, although team decision making plays an important role in all these areas, the approach to the problem has been from that of teams rather than that of decision making. As a result, a clear development of the decision making issues for teams is lacking in this work.

One way to address this shortcoming is to attempt to apply the extensive literature that does exist on decision making to the team setting. As was indicated earlier, this work is primarily focused upon individuals, not teams. Thus, a necessary task for providing such an integration is that of interpreting our knowledge of individual decision making into the demands known to face teams. We address that task in the remainder of the chapter.

Common threads. Although the actors, settings and problems faced by the teams that have dominated interest both practically and theoretically in the last few years differ widely, there are a number of similarities among them. First, the teams are usually composed of members who share a common goal but bring to their teams different knowledge and skills which apply to team subtasks. Not all team members know or understand all phases of the team's task, but they work together with the others to produce an integrated action. Thus, for example, a television news team, with reporters who know little about operating cameras and camera persons who do no reporting, can produce excellent news stories.

The characteristic of differential expertise applied to subtasks within the team and integrated into a team decision has been described as distributed decision making with teams of differential expertise (Vaughn, 1990) and is an important part of most of the teams of interest in the late 1980s and beyond.

A second overarching similarity among these teams is that they operate in high stakes environments. In the case of cockpit crews, the lives of others as well as the team or crew members themselves depend upon their actions. In almost all cases, the teams have a number of complex tasks which must be enacted by coordinating with others and often must be done under severe time and/or resource constraints. Finally, there is a continuity and interdependency within and outside the team that must be maintained in most of the teams of interest. They do not function in isolation. Decisions made at one time must be integrated with the past history of the team, and the potential future consequences of actions cannot be ignored because the team members often must continue to work together. Also, the teams of interest tend not to be isolated from other persons, teams, and organizations. They are typically immersed in a complex web of interdependencies with others.

Our approach to team decision making was designed to attempt to keep in mind the characteristics that are common among the teams of interest. In particular, we shall address teams which focus on, "overall performance where differentiated members

combine resources to make and implement ongoing decisions in high stakes environments characterized by ambiguity, high workloads, time constraints, and systems embeddedness."²

A Model of Team Decision Making

Individual Decision Making

Stevenson, Busemeyer, and Naylor (1990), in a comprehensive and insightful review of individual judgment and decision making, point out that a wide variety of models of individual judgment and decision making represent two general orientations. One orientation is prescriptive or normative. It is the approach typically taken by management scientists, engineers, and statisticians. Models are developed, and decisions are judged against the models with the "correct" decisions representing those that fit the models best. The prescriptive or normative nature of the work attempts to train or in other ways to aid the decision maker to bring decisions more in line with the model (i.e., to make the "right" decisions). The second approach is descriptive and is more likely taken by psychologists, political scientists, and sociologists. In this case, the task is more that of learning how people make decisions and then building models of that decision process. Such models are not presumed to be correct in the sense that they are right or wrong, but they are judged on the degree to which they fit the decisions that people make. Stevenson et al. (1990) argue that decision making requires an interdisciplinary approach that integrates prescription and

description, but they limit their attention to descriptive models. Like Stevenson et al. (1990), we endorse an integration of prescriptive and descriptive approaches to decision making, but we also build our model on a descriptive one from the individual decision and judgment literature.³ However, we shall return to some prescriptive issues after presenting the model.

The individual model chosen for adaptation to group decision making was a correlational model first developed by Brunswik in the 1940s and 1950s (Brunswik, 1940; 1943; 1955; 1956) and labeled the Brunswik Lens Model by many since that time. The model is best described by the use of the figure, adapted from Blum and Naylor (1968), and presented here as Figure 1.

The model construes decisions as resulting from the evaluation of a finite set of cues or predictors represented by the vector of X s in the center of the figure. Each X represents a value on some cue dimension. For example, if the decision involved the selection of a job applicant from a number of candidates, X_1 might be previous experience and the value (x_{11}) might be time in years. From the set of predictors, there are two sets of decision making rules. Each set is represented by a function (typically linear) where the cues are combined and weighted to lead to a decision. Using the job applicant selection example, the decision would be that of selecting the applicant, and the function would be the description of the combination rule for weighting all the cues to make a select/reject decision on

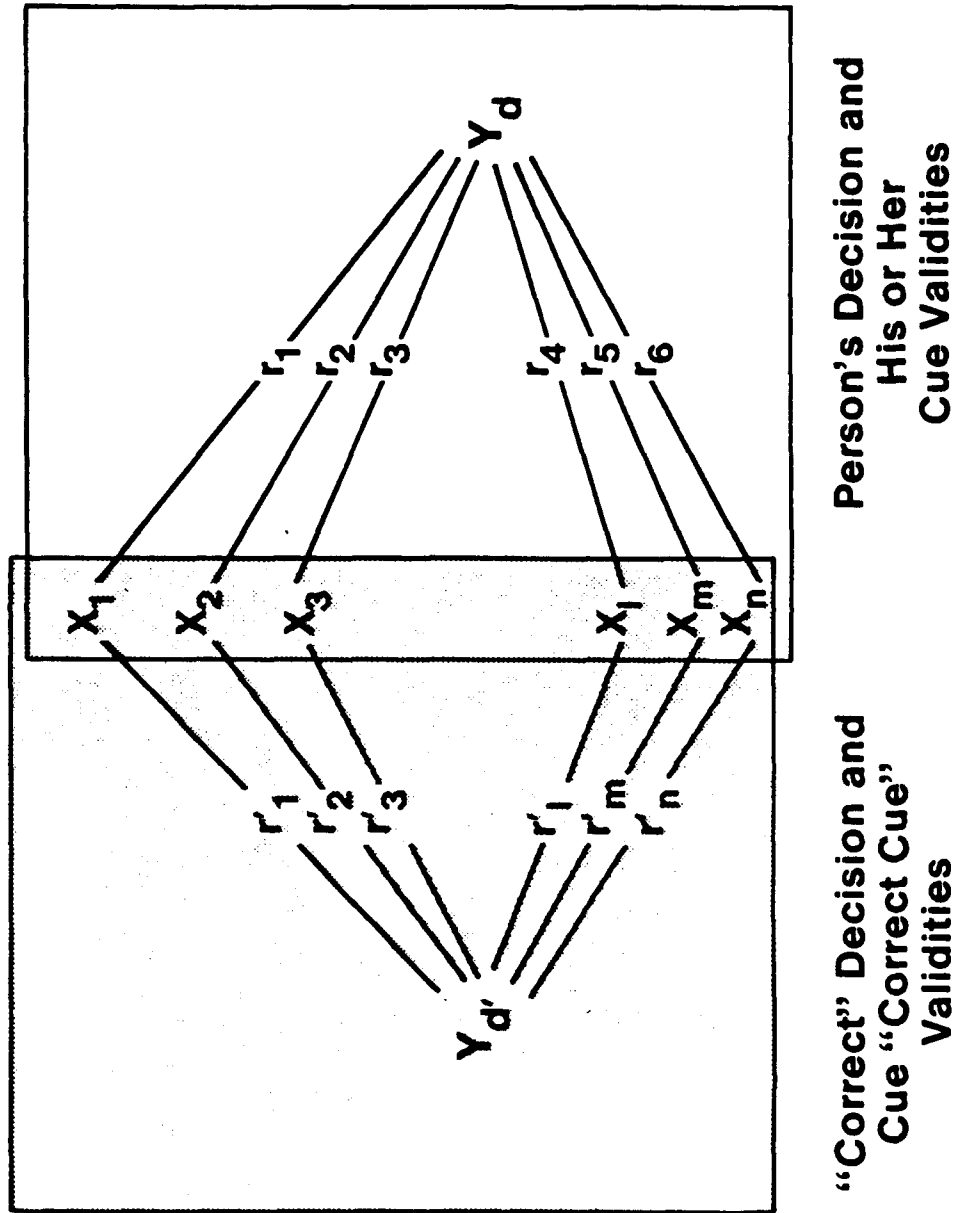


Figure 1. Brunswik Lens Model of Decision Making. Modified from

Blum and Naylor (1968), p. 456.

each applicant. In Figure 1, the shaded region represents one function and the unshaded another. The symbols, r_1' and r_1 , represent the weights of the cues in the respective functions with respect to the contributions of the cues to the final decision.

The shaded portion of Figure 1 represents the set of predictors ($X_1 - X_n$), a criterion (Y_d'), and a set of linear weights ($r_1' - r_n'$) for the predictors of the criterion. For the typical research paradigm using the model, the linear model relating predictors or cues to the criterion is known. That is to say, if the model were used as shown to study selection decisions, decision makers would be presented with a number of applicants, each with values on each of the n cues, and the researcher would have created, a priori, a particular functional relationship between the cues and the criterion. For the given problem, the a priori model is considered the "correct" model to which the decision maker's choices would be compared. Individuals would then be presented with a number of applications and asked to make selection decisions.

With the combination of the known cue values represented by the applicants and the decision-maker's decisions regarding each applicant, the linear equation for the way the decision-maker used the cues to make decisions can be generated. This is represented by the weights ($r_1 - r_n$) in the unshaded area of Figure 1. Finally, by making a number of comparisons within or across the "correct" and the decision-maker's model, a number of interesting

theoretical and practical questions can be addressed. For example, if X_1 represents previous experience in a selection problem, a comparison of r_1' to r_1 will provide information about whether or not the decision maker puts more or less weight on previous experience than the a priori model says he or she should. Although there are a large number of ways the model is used, comparisons within it constructed, and cues generated, Figure 1 provides a basic construal of some of the primary elements of the model.

The decision model outlined in Figure 1 is based on the assumption that individuals are rational decision makers who obtain information on the relevant set of cues for any particular decision, assign weights to the cues and reach decisions. Under ideal conditions, decisions can be shown to follow the model quite closely. However, under most conditions, the gap between the correct model on the left and actual decisions on the right is not small. A large body of research exists that offers explanations for the gap between the two models. Much of this relies on the assumption that human information processing capabilities are limited. As a result, people simplify the decision process.

March and Simon's (1958) notion of satisficing rather than optimizing is based on the observation that people cannot search all alternatives (i.e., cannot identify all cues or observe all combinations of cue values) and select the best alternative. Rather they search until they have found one or two (a few) that

clear their criterion of acceptability and then they select that alternative. Similarly, Kahneman and Tversky (1973) stimulated a great deal of research on biases in decision making that resulted from the simplifying strategies they labeled heuristics. Their descriptive research was aimed at identifying and labeling heuristics and describing the types of effects particular heuristics had on actual decisions. Much of the recent work on individual decision making has focused on heuristics and other decision biases predicated on the assumption that the information processing demands of most decisions are far from simple and are often beyond human capacity thus requiring individuals to simplify the process.

A Team Lens Model

Brehmer and Hagafors (1986) argued that, when organizations are faced with complex decision problems, the most common way of simplifying them is to assign the complex decision to a staff of experts. The experts divide the larger problem into a number of subproblems each of which is assigned to an expert. Brehmer and Hagafors' (1986) model, presented in Figure 2, is a special case of such a situation in which the complex problem represented by the column of cues is subdivided into sets of two cues assigned to each of three individuals. These individuals reach individual decisions in their own area of expertise (i.e., in the area represented by the two cues assigned to them). Their decisions serve as inputs (cues) for the leader who makes a decision for the

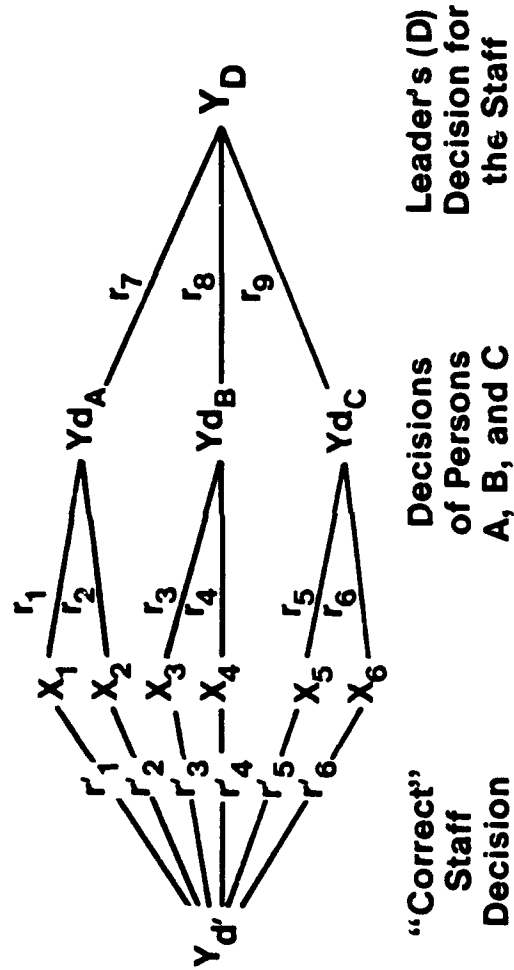


Figure 2. Brehmer and Hagafors' Model of Staff Decision Making.
Modified from Brehmer and Hagafors (1986), p. 183.

staff. Under such conditions, the subordinates make a decision on two cues and the leader needs only to consider the three decisions from his or her subordinates' cues for reaching a decision for the staff.

In a laboratory study designed only to be illustrative of some empirical issues that could be addressed in the model, Brehmer and Hagafors (1986) varied the validity of the initial set of cues and the validity of the subordinates' decisions. Only leaders were used as subjects; subordinates' decisions were experimentally manipulated by providing each leader with decisions supposedly made by subordinates who had seen particular cue values. A number of interesting findings resulted. For example, if one subordinate made less valid decisions than the other two, when presented with the cues themselves rather than the subordinate's decision, the leaders underutilized cues that were the responsibility of the less reliable subordinate. The interesting general finding, in our opinion, was the fact that it was not easy for leaders to learn how to make good decisions under the staff structure condition. It was not at all clear that the hierarchical structure simplified the decision process for the leader. Clearly, there is a lot more to be learned. Unfortunately, little has been done to study staff decisions either under the simple model represented in Figure 2 or more complex ones that match a wider set of staff/team situations.

A Distributed Decision Making Model of Team Decision Making

The model. By their own admission, Brehmer and Hagafors' (1986) model represented a very limited team adaptation of the social judgment model of individual decision making. In particular, it was limited to team decisions (labeled staff decisions by the authors) in which subordinates had exclusive access to a limited subset of information (cues), and team leaders based the team decision only upon the inputs of their subordinates. In addition, to our knowledge, the one study based on the model was limited to how team leaders learned to make decisions. While team learning is an extremely important part of team decision making processes, it is not the only important one.

Our goal was to build upon a lens type model of decision making by both modifying the basic structure in ways that represent team decision making when expertise is distributed across members and extending the team processes of interest beyond those of learning. To describe the team model, we first begin with characteristics of a hierarchical team and build onto it a decision making structure.

Figure 3 illustrates a hierarchical decision making team with four members. Such teams have three primary characteristics. The first of these is that of hierarchy; team members are not of equal status. In the illustration, member D is of higher status with the other three members reporting to him or her. As drawn, the other three members do not differ in formal status. The

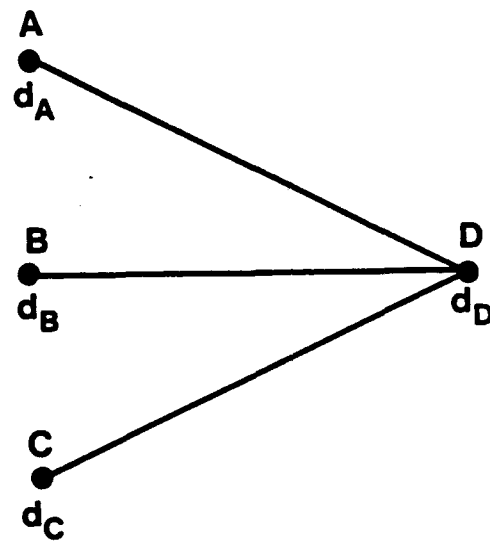


Figure 3. Hierarchical Decision Making in a Four Person Team.

second feature is that the primary task of the team is to make decisions. In the case illustrated, each of the subordinate members reaches a decision or judgment ($d_A - d_C$), and the subordinate's recommendation is passed to the leader who also makes a decision (d_D). Typically, and as is the case in Figure 3, the leader's decision represents the decision of the team.

Figure 4 builds upon the hierarchy of Figure 3 by introducing a new construct, distributed expertise. In the example illustrated in Figure 4, the distribution of expertise in the team is represented by the allocation of critical information regarding the decision to individuals in the team. The pattern of distribution represents the expertise system. On the far left of Figure 4 is a column of cues (X s). As was the case at the individual level, each X is a vector element where the elements (x_i) represent specific values on the dimension for each of the decisions. Expertise is represented in the figure by the association of information with individuals. Individuals' areas of expertise are construed to be described by the pieces of information to which each person has access. In Figure 4, Person A is an expert in the knowledge domain represented by X_1 and X_2 , Person B by X_2 , X_3 , and X_4 , Person C by X_5 and X_6 , and the leader by X_1 and X_6 .

Note that it is not necessary for information to be the unique property of one person. In the example of Figure 4, information on Dimension 2 is available to both Persons A and B,

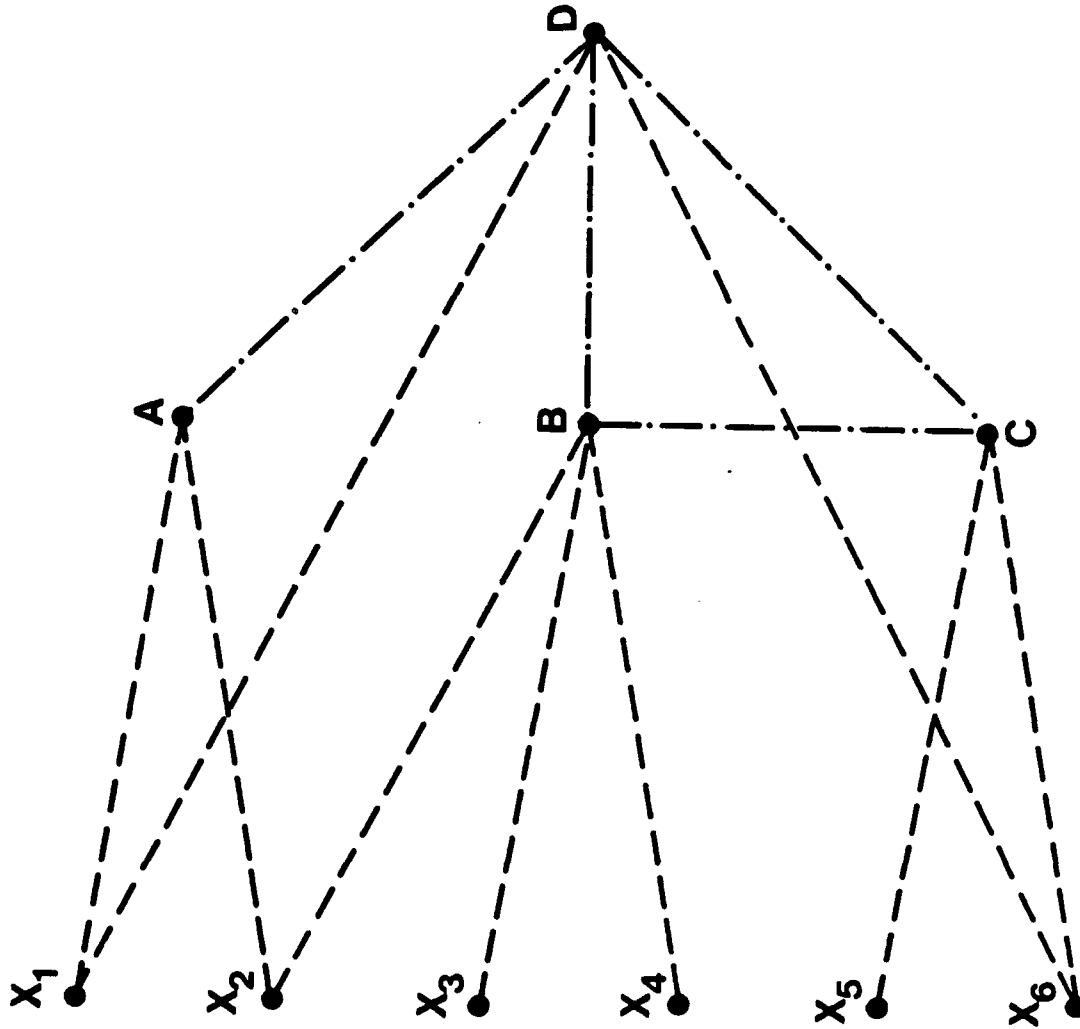


Figure 4. A communications Structure for a Four Person Team.

and the leader has direct knowledge about both 1 and 6 even though those dimensions are known by Persons A and C, respectively. Thus, although the distribution of expertise is represented by the way in which information is allocated to every member of the group, it is not necessary that all of the information be available to only one of the team members. On the other hand, it is also not acceptable to have all members of the team have direct access to all of the relevant information if the expertise in the team is to be distributed. In other words, when everyone knows all information without getting some of it from other team members, the level and nature of expertise in that group is not considered to be distributed within the team as a matter of definition.

Figure 4 introduces one other important feature of teams--a communication structure. By definition, communication structures exist among persons. The one illustrated in the figure shows Person A being able to communicate directly only with the leader, Person D. Persons B and C can communicate directly with the leader and with each other. Finally, the leader communicates directly with each of the subordinates A, B, and C. In this team, it is still possible for all persons on the team to communicate with all others, but, for Person A, the communication with Persons B and C is indirect. That is, A must go through D to get messages to and from the other two subordinates. Persons B and C must do the same to get messages to A.

According to our model, the combination of the communication system with the expertise system provides the structure within a team for potential access to information by each team member. Take, for example, Person B in Figure 4. This person may access information on X_2 , X_3 , and X_4 directly. The person is one step removed from information on X_5 and X_6 ; he or she can ask Person C for that information, assuming that Person C honors Person B's request, and, for X_6 , the same could be done through the leader. Finally, Person B can access information on X_1 indirectly by going through two persons, first the leader who could then go through Person A to get the information and relay it back to B. A similar two step indirect path exists from B through the leader and Person C to information on X_5 . In most cases, however, it would appear to be more efficient to get that information by going directly to Person C.

With Figure 4, we have incorporated distributed expertise into a team hierarchy in such a way as to provide a structure for describing how information becomes available to team members for making decisions. The availability of information relevant to a team decision represents a necessary but not sufficient condition for reaching a decision. The remainder of the process involves the decision itself. In particular, the concern is with how the information is used by the team to reach a decision and with the quality of the decision. In order to evaluate the latter, decision making research typically has used decisions for which

the quality of decisions can be evaluated against criteria established a priori.

Figure 5 introduces the decision process to the combination of the hierarchy of Figure 3 and the expertise and communication systems of Figure 4. As was the case in the first two figures, six dimensions of information are used to reach a decision ($X_1 - X_6$). Working left from the X_i s, the a priori or "correct" decision is represented by Y_d' . The lines between the dimensions of information and the decision represent the extent to which each one of the dimensions is related (contributes) to the decision. In the individual decision making literature using the Brunswik Lens model, a linear regression model is used to relate dimensions to decisions. Regression weights are chosen a priori, and then sets of cues and decisions are generated to match the chosen model. The team construal of the decision model represented in Figure 5 is exactly analogous to this. Here, a set of cue values are generated along with a set of decisions in order to fit an a priori model, and the model generated from the same set of cues presented to the group is represented in the left hand portion of Figure 5. The Y_d' is the "correct" decision to which the team's decision can be compared.

The right hand portion of Figure 5 represents decisions made in the team. As illustrated, there are two sets of decisions. The first of these includes the decisions made by Persons A, B, and C, symbolized by Y_{dA} , X_{dB} , and Y_{dC} . The figure illustrates the

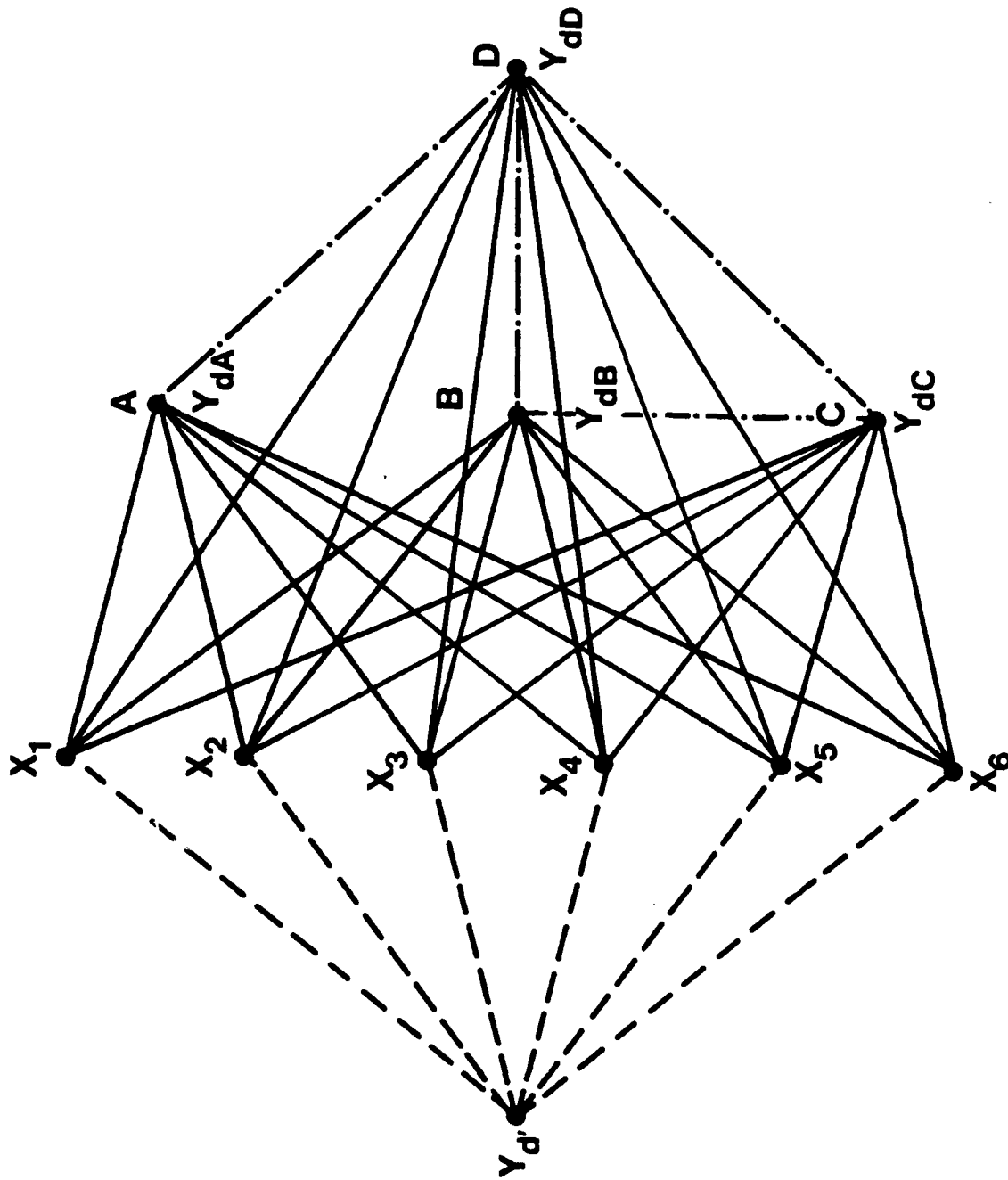


Figure 5. Hierarchical Decision Making in a Four Person Team with Distributed

Expertise.

case in which all six sets of information are used by each team member to make a decision. Each team member's decision can be represented or captured by regressing the individual's decisions on the cues presented to him or her. The second decision is that of the leader. This decision has the potential for being a little more involved than the subordinate decisions in a group structured in the hierarchical fashion illustrated. One way for the leader to make a decision is exactly the same as that of the subordinates. That is to say, the leader can base his or her decision upon a linear combination of the six cues. However, unlike the subordinates, in the configuration illustrated in Figure 5, the leader has access to the decisions of each of the subordinates in addition to access to cue information. Thus, the subordinate decisions are analogous to cue dimensions for a decision by the leader based on three cues. Therefore, the leader's decision can be modeled as a function of the three subordinates' decisions. The leader's decision can also be modeled as a function of the individual cues. Within the team decision-making model presented here, one way to evaluate the accuracy of either the leader's/team's decision and/or those of the team members is to compare them to the decisions judged a priori to be most appropriate, specifically, to compare Y_{dA} , Y_{dB} , Y_{dC} , or Y_{dD} to Y_d .

The three figures just described complete the conceptual framework of our model for decision making in hierarchical teams

with distributed expertise. Onto this framework can be mapped a large number of team and individual constructs that are likely to play a major role in team decision making. At the individual level, for example, it can be argued that team members' abilities will affect the decisions of both the persons and the team. At the team level constructs such as conflict, coordination, cooperation and climate have been shown to be important. Our research on teams incorporates these and other individual and team constructs to study team decision making when the decision making task is modeled by the structures introduced in Figures 3, 4, and 5.

An experimental paradigm. To study team decision making under conditions of distributed expertise, a four person team exercise was developed. (See Hollenbeck, Sego, Ilgen, and Major, 1991, for a complete description of the task.) On the task, each team member is assigned to a specific role and is responsible for reaching a decision. Early work with the task involved role playing a command and control unit in a Naval setting with responsibility for monitoring an airspace and making decisions about unidentified aircraft entering airspace unannounced. As is clear in Hollenbeck et al. (1991), although a naval task is used, it can be easily modified to deal with a wide variety of team decision tasks where team members hold different roles, such as a four person task force comprised of an engineer, a union representative, a production manager and a purchasing agent who

are to make decisions about the purchase of industrial robots. The general team program goes by its acronym, TIDE², for Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise.

For illustration purposes, consider a configuration of TIDE² that was used in an initial study. The simulation assigned people to four roles within a team with three of the roles subordinated to the fourth. The three subordinate roles were to monitor a "sea screen" for unidentified aircraft. One subordinate was supposedly located on land at a Coastal Air Defense station (CAD), another on a cruiser, and a third in a reconnaissance aircraft (AWAC). The team leader was located on an aircraft carrier. When an unidentified aircraft came into the area, all were to gather information about it, reach independent decisions about what to do, and send their decisions to the team leader who would reach a decision for the team regarding the reaction to the unidentified aircraft. The decision was expressed in terms of the level of threat the team felt the unidentified aircraft represented. Training on the task provided the leaders with specific information about how threat was determined. In the jargon of the model, the training specified the cues and the way the cues should be weighted to decide on level of threat. Thus, while the purpose the individual use of the Lens Model described earlier was to discover the way individuals learned how to combine

cues, in this case team members were told how to do it. The focus here was, on how well they used the rules they had been taught.

Nine types of information (cues) were available to the teams. These were such things as the speed of the aircraft, its angle of flight with regard to the team's location and its altitude. The types of information are represented by the numerals in Figure 6. In particular, each subordinate had direct access to five pieces of information, two of which were also available to one of the other subordinates but not both and one of which was available to the leader but no other subordinate. Thus, for example, the person in the AWACs could directly measure 1 - 5, but he or she had direct access exclusively to no item, shared access to Item 3 with the leader, and shared access with the cruiser for Items 4 and 5. For the person on the AWACs to learn about the values of other cues (6, 7, 8, or 9), he or she had to communicate with one of the persons who had that information and that person had to share it with him or her. Expertise was defined by the cues to which a person had direct access and, therefore, some control over the extent to which other team members learned about this information.

All team interaction went on through a networked computer system. An unidentified aircraft appeared on the screen of all four team members simultaneously. Team members were to interact with each other and then to make decisions which were sent to the leader for the overall team decision. Once a decision was made

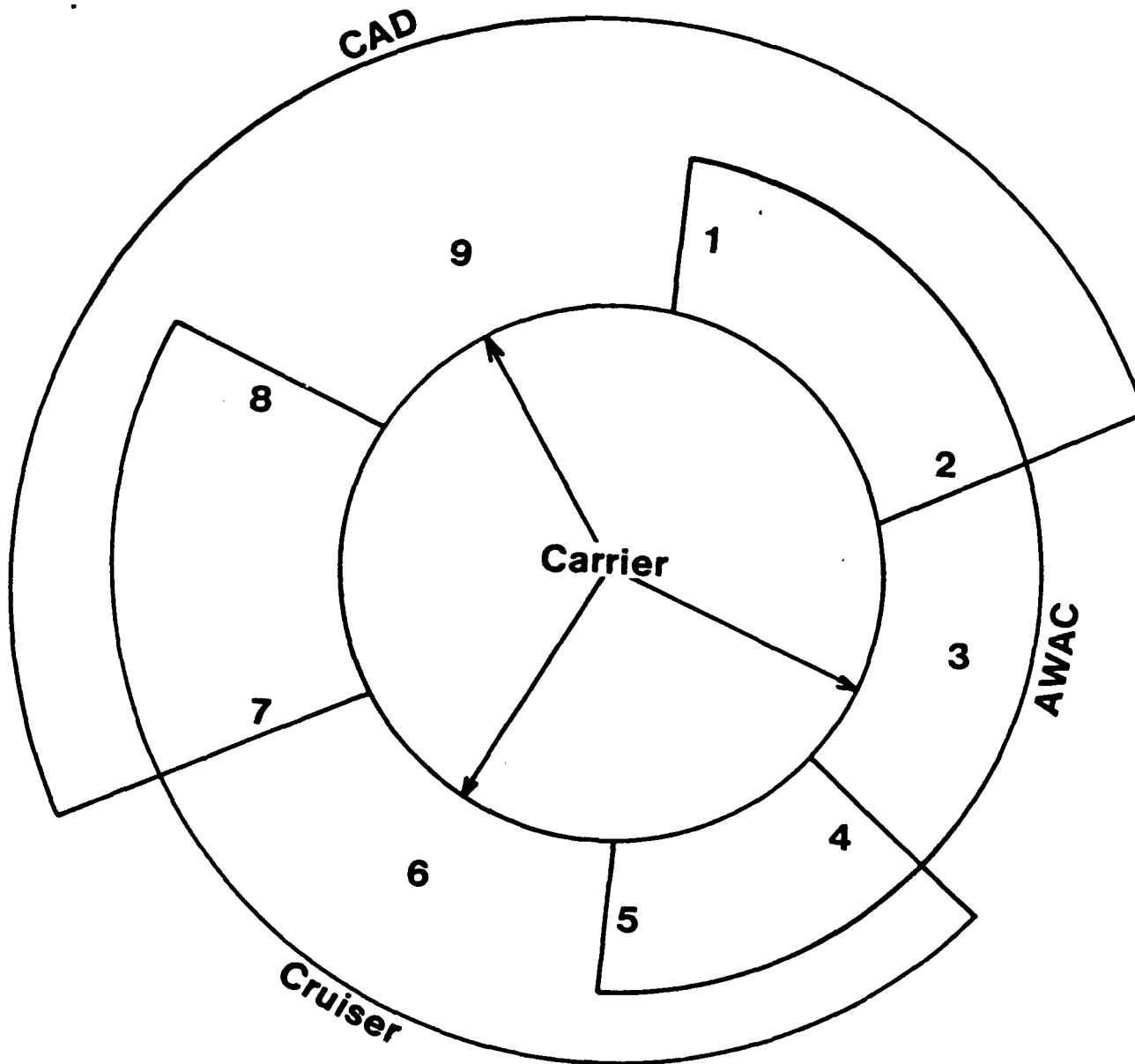


Figure 6. Allocation of Nine Cues to Four Roles in a Team Decision Making Simulation Exercise.

for the team, the decision appeared on the screen of all members along with feedback regarding the quality of the decision based on rules that they had been taught prior to engaging in the exercise.

Using the above paradigm, a wide variety of team decision making problems can be investigated. The ecological validity of the cues in a particular study can be created by the way in which the cue values are selected and the rules described to them. The rules provide the basis for establishing the cue weights. The actual weights and the decisions made by each team member and the team leader can be captured from observing the decisions that are made. Furthermore, team processes such as cooperation, collaboration, and other patterns of interaction can be captured from measuring the patterns of communication in the team. Thus, in our opinion, the paradigm is very flexible allowing for the study of a wide range of team decision making processes and other processes that influence the quality of team decisions.

Potentialities. In many respects, the decision making literature at the individual level is parochial. This is illustrated in the introduction of the comprehensive review of Stevenson et al. (1990). These authors describe two major dimensions of decision making as that of problem solving versus decision making and that of descriptive versus prescriptive decision models. In the problem solving case, persons are confronted with a problem and must generate the issues or dimensions on which they will seek information, then reach a

decision regarding their approach to the problem. For decision making, the information set is fixed, and individuals make decisions or choices based on a fixed set. Although it is readily accepted that decision making is a subset of problem solving and that many more problems are likely to be of the problem solving nature than purely decision making, there tends to be little integration among the works in problem solving with those in decision making. In terms of sheer volume of research, the decision making work far outweighs that in problem solving in spite of the reverse in terms of naturally occurring events. A similar isolation exists between a second major dimension of decision making, descriptive versus prescriptive decision models. In the former case, interest is in observing decisions and fitting the observed behavior as best as possible to a particular model. In the latter case, a model is selected a priori, and behaviors are observed and then fit to the model as closely as possible under the assumption that the model represents a good way to make decisions. As Stevenson et al. (1990) point out, not only is the emphasis very different, but the researchers involved in each tend to come from different disciplines--social/behavioral sciences for the descriptive and engineering/mathematics for the prescriptive ones.

We are suggesting that the model presented above is capable of studying the broader issues of problem solving with some of the precision of decision making. In addition, it can be used in both

a prescriptive and descriptive fashion. Problem solving exists to the extent that individual experts have the freedom to choose whether or not they access particular pieces of information rather than being presented with all the information. Problem solving also occurs to the extent that teams evolve strategies to deal with making decisions. In the latter case, the teams develop patterns of interaction in terms of who speaks to whom about what information and create problem solving strategies to reach decisions. At the same time, by presenting the team with decision making tasks that have external criteria for the correctness of the decision (i.e., the ecological validity can be determined), the decision making variables can be studied within the framework of problem solving, a framework that we would argue is far more frequently encountered by teams than is the strictly decision making one.

By studying team decision making over time within the above paradigm, both prescriptive and descriptive elements of decision making can be integrated. Problems with known solutions (judgments) and strategies for reaching decisions can be studied over time in a descriptive sense to see how the teams perform the decision tasks. Through training and other means for structuring the problem, prescriptive processes can be presented to the teams and their performance evaluated against them.

We believe that the model coupled with the experimental paradigm also allows for the use of a wider variety of research

methods than has been typically encountered from any one decision making perspective. Ford, Schmitt, Schechtman, Hults, and Doherty (1989) made the common distinction between structural or statistical modeling in decision making where the focus is on the relationship between information (cues, inputs) and decision responses (judgments, outputs) and process models that work to discover how decision makers get from inputs to outputs. They correctly point out that the two foci are rarely integrated into the same research studies, and yet, the two approaches are potentially complementary, not mutually exclusive. The paradigm presented here offers the opportunity for such integration. On the one hand, the ability to create decision structures for teams allows for the evaluation of the effectiveness of structural models for capturing the decisions of teams presented with a number of tasks with known cues and cue values. On the other, it allows for capturing the processes used by the teams to reach those decisions by measuring the intermediate steps taken by the teams as they interact to share information about the cues, team interaction process and other information in the process of reaching a decision.

Team Decision Making: An Issue of Levels of Analysis

As has been stated all along, ultimately we are concerned about the decisions of teams that are embedded in larger organizational systems. The embeddedness of individuals in teams and teams in organizations, by necessity, raises both conceptual

and methodological issues related to levels. For a long time, those in the organizational sciences treated levels rather cavalierly. For the most part, the issues were simply ignored. However, Roberts, Hulin, and Rousseau (1978) and others (Dansereau, Alutto, Markham, & Dumas, 1982; James, 1982; Roberts & Burstein, 1980) have demonstrated that the failure to consider the level of analysis for constructs and measures can have serious consequences. The problems of levels are particularly important in the present case where constructs at one level, in this case at the level of the individual, are being translated into team level phenomena, and yet team decisions are still comprised of individuals, albeit individuals acting in some form of a collective.

Rousseau (1985) presents an excellent description of types of biases confronted when multiple levels are involved in research and theorizing, and she also provides a taxonomy for constructs that most frequently are of interest in research that is confronted with multiple levels. It is this taxonomy that is of most interest to us here. In particular, she describes three forms of models for constructs that arise in cross-levels research and theory such as is the case when the interest in decisions made by teams (one level) of individuals (another level) acting in concert. The first of these are composition models. Composition models specify functional relationships between variables where the variables themselves are conceptually located at different

levels, and the constructs at each level are functionally similar, although not necessarily, identical. In the case of team decision making, we have argued that the decision process at both the individual and team level involves the consideration of cues. The cues are weighted by the decision maker, and the weights function similarly at the individual and the team level but not identically. For example, the leader's decision, at the team level, is based on weights that are influenced by judgments about the reliability and validity of the subordinates whose judgments the leader uses as cues for his or her decisions. In this sense, there are compositional issues as one moves from individuals to teams, and these issues, if ignored, can be misleading. Certainly, it can be misleading to assume that the team decision processes regarding cue weights are simple analogues of individual ones.

A second form of cross-level models involve hypothesized functional relationships between a variable at one level with a variable from another. These are termed cross-level models by Rousseau (1985). Numerous examples of such cases exist for team decision making such as the introduction of team member abilities into models predicting the quality of team decisions. In this case, abilities are individual characteristics which, by definition, are at the level of the person, and team performance is a team output.

Finally there are multi-level models (Rousseau, 1985). In this case, the relationship among variables is predicted to generalize from one level to the other. Again, many of the relationships that we described earlier between cues, weights and decisions or choices were based on the assumption that the nature of the relationship observed at the individual level would generalize to that of the team.

The importance of the levels issues is that, depending upon the nature of the model that is being assumed for the constructs of interest, there are both methodological and conceptual issues that must be taken into account to avoid biases and misinterpretation of results. Since team decision making, by its very nature involves at least three levels, individuals, aggregates of individuals, and tasks/environments, issues of levels cannot be ignored. Therefore, as research is generated based on this model or any other model, levels must be considered. Fortunately, both conceptual (e.g., Rousseau, 1985) and empirical (e.g., Dansereau, Alutto, & Yammarino, 1984) advances have improved our ability to address the levels issues that have been ignored in much of the earlier work on teams.

Conclusion

If one accepts, as we do, that many situations today and in the near future will require people to work in teams in which differentiated members combine resources to make and implement ongoing decisions in high stakes environments, then it is critical

that we understand the decision making capabilities of such teams. Such understanding is necessary to be able to construct teams with members who have the skills and abilities to carry out team tasks. It is also necessary to understand team functioning to be able to construct team tasks in such a way that the task demands are within the capabilities of persons working in teams. Finally, if individuals are to be trained to operate in teams or if decision aids are to be developed to foster the effectiveness of teams operating in the kinds of environments just mentioned, there must be a body of knowledge that guides the development of task design, training, and decision aids if these practices are to enhance team effectiveness.

Although a great deal of work exists on both decision making and team functioning, it was argued that this work is limited in the extent to which it speaks to the issues of teams operating in the types of environments that were of interest here. There were a number of reasons for these limitations. First, the vast majority of studies on decision making are limited to individual rather than team decision making. Second when teams are studied, much of the work focuses on internal team processes without regard for team performance. Often when teams were asked to perform tasks, performance on the task was only used as a condition to observe team process; task performance was not of interest. Finally, when models of team performance were built, they often either dealt with specific performance situations that have

limited generalizability to teams in ongoing organizational settings of interest here, or the tasks were very abstract and thus quite far removed from the tasks of ongoing teams. Excellent models of team performance that tend to fit in the two sets just mentioned are those related to jury decision making (e.g., Davis, Holt, Spitzer, & Stasser, 1981) and the work of Laughlin (Laughlin & Adamopolis, 1982).

Recent research on cockpit crews (Foushee, 1982; 1984; Hackman, 1987; Gregorich, Helmrich, & Wilhelm, 1990), problem solving groups (Gersick, 1989), and training teams (Morgan et al., 1986) involves team members making decisions in settings that more closely approximate those identified as the focus of our concern. Yet, while this research is a better match as to setting, it trades off the setting for precision in construct measurement and model development offered by the research programs on jury decision making and group problem solving offered by systematic research programs of persons such as Davis and Laughlin, respectively. Such tradeoffs are inherent in behavioral research (Runkel & McGrath, 1972), and well reasoned positions can be made for either extreme. However, these reasons should not preclude attempts to combine some of the advantages of both.

The model and research paradigm presented here represents a compromise between the two extremes. The model itself provides a structure that can guide research that studies team decision making under conditions where there exist external standards for

team effectiveness. That is to say, team effectiveness criteria exist for evaluating team performance. Furthermore, the model is one that fits the decision making tasks of a number of diverse teams from command and control teams in military settings, to ad hoc teams composed of members with differing expertise put together to make one time decisions such as purchasing a new computer, to ongoing teams of experts faced with day-to-day decisions such as the case of emergency room staff making admission and treatment decisions under stress. The task simulation based on the model provides a setting in which hypotheses derived from either the model or from situational conditions faced by teams of the type we have described can be investigated.

Like any model and any paradigm, the one proposed here also represents trade-offs. Traded off is the precision of the decision making models that restrict the decision domain to those situations where all cue values and their distributions are known. Also lost is the breadth of concern for emerging team constructs that could be observed on tasks for which no standards of performance are known. Finally, some of the naturally occurring events that are likely to be important in any team operating in real life environments are lost when teams in simulations are used. At the same time, it is our belief that, at the present time, given the importance of understanding decision making in the kinds of teams identified as important in modern organizations,

the model and the paradigm fill a crucial vacuum by capitalizing on some of the advantages of model driven research in the laboratory and simulating critical field conditions. Research is currently being conducted on the model using the paradigm. Soon, we and others will be able to judge the validity of our beliefs about the value of the model and paradigm.

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Footnotes

¹Even the basic assumption of finite must be qualified.

Such sets of information are often only finite in the sense of the individual's use of them. In actuality, there may be an infinite number of dimensions of information that have some relevance to a decision. At the same time individuals may treat them as if finite or at least probabalistically finite.

²We owe this description of the nature of teams of contemporary concern to long discussions at a conference held at the University of Maryland in February, 1991, and hosted by Richard Guzzo and Eduardo Salas.

³In the decision making literature, decision and judgment are used interchangeably. We shall do the same, but, in an attempt to avoid confusion, we shall use the term decision most of the time when we mean either a decision or a judgment.

DISTRIBUTION LIST*

Ms. Lisa B. Achille
Human Computer Interaction Laboratory
Code 5530
Naval Research Laboratory
Washington DC 20375-5000

Dr. Janis Cannon-Bowers
Naval Training Systems Center
Code 262
12350 Research Parkway
Orlando, FL 32826-3224

Dr. Clint Bowers
Department of Psychology
University of Central Florida
Orlando, FL 32816

Dr. Katherine Carley
Department of Social
& Decision Sciences
Carnegie-Mellon University
Pittsburgh, PA 15213

Dr. Susan Chipman
Cognitive Science Program
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Dr. Michael Drillings
Basic Research Office
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Dr. LorRaine Duffy
Ground Operations Branch
AFHRL/LRG
Wright Patterson Air Force Base,
Ohio 45433-6503

Dr. Steve Hinkle
Department of Psychology
Miami University
Oxford, Ohio 45056

Mr. Kent Hull
Decision Science Consortium, Inc.
1895 Preston White Drive
Suite 300
Reston, VA 22091-4369

CAPT Thomas N. Jones
Naval Medical R&D Command
NMRDC 404, Bldg 1, Tower 12
Bethesda, MD 20814-5044

Dr. John Jonides
Department of Psychology
University of Michigan
330 Packard Road
Ann Arbor, MI 48104

Dr. Gary Klein
Klein Associates Inc
800 Livermore Street
P.O. Box 264
Yellow Springs, OH 45387

* If you are interested in this line of research and would like to be added to our mailing list, please contact Daniel R. Ilgen, John A. Hannah Professor of Psychology & Management, Department of Psychology, Michigan State University, East Lansing, Michigan, 48824-1117.

Prof. D. L. Kleinman
Dept of Electrical
& Systems Engineering
Room 312
260 Glenbrook Road
Storrs, CT 06269-3157

Dr. Donald L. Lassiter
Dept of Psychology
University of Central Florida
Orlando, FL 32816

Dr. Paul Lehner
Dept of Information
Systems & Engineering
4400 University Drive
Fairfax, VA 22030

Dr. Alan M. Lesgold
University of Pittsburgh
Learning Research
& Development Center
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. John M. Levine
University of Pittsburgh
Learning Research
& Development Center
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Alexander Levis
Laboratory for Information
& Decision Systems
Massachusetts Institute of Technology
Room 35-410
Cambridge, MA 02139

Mr. Gerald S. Malecki
Cognitive & Neural Sciences Division
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Ben Morgan
Department of Psychology
University of Central Florida
Orlando, FL 32816-0150

Dr. Michael F. O'Connor
Decision Science Consortium, Inc.
1895 Preston White Drive
Suite 300
Reston, VA 22091-4369

Dr. Judith Orasanu
Psychology Department - Green Hall
Princeton University
Princeton, NJ 08544-1010

Dr. Garold Stasser
Department of Psychology
Miami University
Oxford, OH 45056

Dr. Eduardo Salas
Code 262
Naval Training Systems Center
Orlando, FL 32826-3224

Dr. Daniel Serfaty
Manned Systems Group
Alphatech Inc
50 Mall Road
Burlington, MA 01803

Dr. Maring A Tolcott
3001 Veazey Terrace, Apartment 1617
Washington, DC 20008

Dr. Willard S. Vaughan, Jr.
Cognitive & Neural Sciences Division
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217

Dr. Ruth Willis
Naval Training Systems Center
Code 262
12350 Research Parkway
Orlando, FL 32826-3224

Dr. Sam Schifflett
AL/CFT Building 170
Brooks AFB, TX 78235

Dr. Edward J. Conlon
Department of Management Sciences
University of Iowa
465 Phillips Hall
Iowa City, IA 52242

Dr. Lee Roy Beach
Department of Management & Policy
The University of Arizona
Tucson, AZ 85721

Dr. J. Richard Hackman
Harvard Business School
Morgan 230
Boston, MA 02163

Dr. Ruth Kanfer
Department of Psychology
N218 Elliott Hall
University of Minnesota
Minneapolis, MN 55455

Dr. Howard Klein
Faculty of Management
Ohio State University
341 Hagerty Hall
Columbus, OH 43210-1399

Dr. Anne O'Leary-Kelly
Department of Management
Texas A&M University
College Station, TX 77843-4221

Dr. Edwin A. Locke
College of Business & Management
University of Maryland
College Park, MD 20742

Dr. Larry L. Cummings
Carlson School of Management
University of Minnesota
271 19th Avenue, South
Minneapolis, MN 55455

Dr. Howard Weiss
Department of Psychological Sciences
Purdue University
West Lafayette, IN 47907

Dr. Elizabeth Weldon
Organizational Behavior
Kellogg School of Management
Northwestern University
Evanston, IL 60201

Dr. Joseph McGrath
Department of Psychology
University of Illinois
603 East Daniel Street
Champaign, IL 61820

Dr. James H. Davis
Department of Psychology
University of Illinois
603 East Daniel Street
Champaign, IL 61820

Dr. Norbert Kerr
Department of Psychology
Michigan State University
East Lansing, MI 48824-1117

Dr. Karl E. Weick
School of Business
University of Michigan
Ann Arbor, MI 48109-1234

Dr. Terence R. Mithchell
Management & Organization
School of Business
University of Washington
Seattle, Wa 98195

Dr. Richard A Guzzo
Department of Psychology
University of Maryland
College Park, MD 20742-4411

Dr. Michael D. Covert
Department of Psychology
BEH 339
University of South Florida
Tampa, FL 33620-8200